

Scalable Visualization Clusters

using commodity hardware

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ACTS workshop on the DOE Advanced
Computational Software Collection

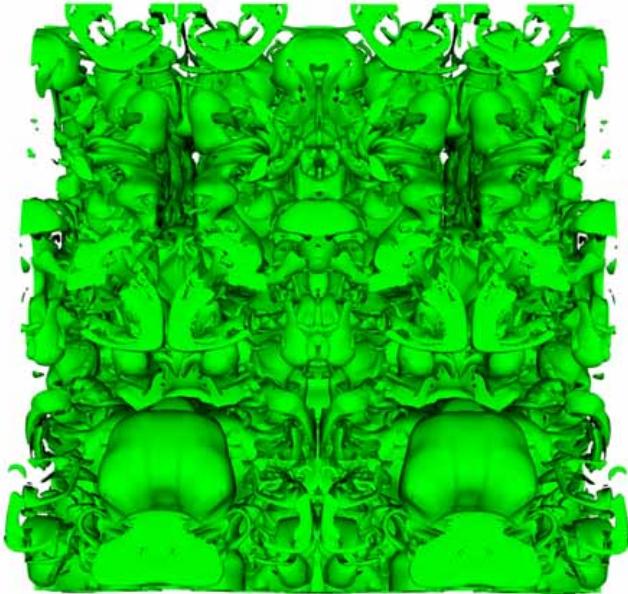
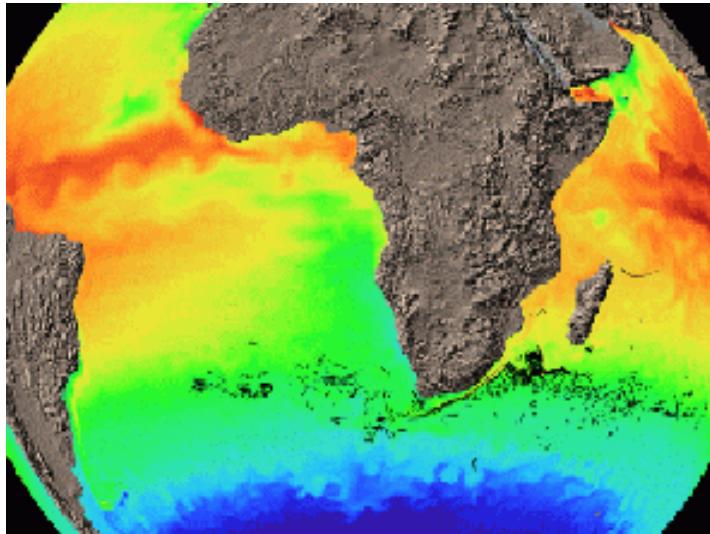
September 7, 2002

Lawrence Berkeley National Laboratory

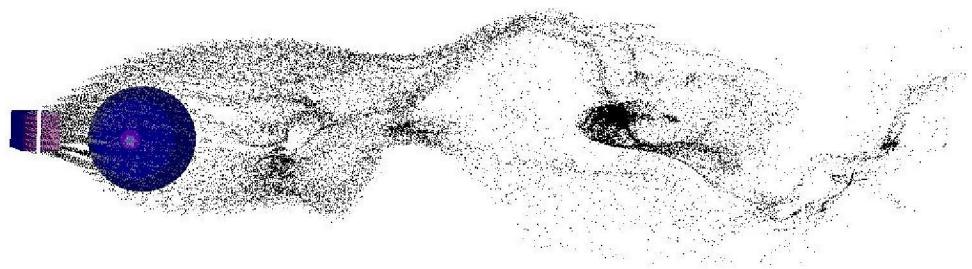


References – in proceedings

- IEEE Parallel and Large-Data Visualization and Graphics Symposium (2001)
Scalable Interactive Volume Rendering Using Off-the-Shelf Components
S. Lombeyda, L. Moll, M. Shand, D. Breen and A. Heirich
- Eurographics 4th Workshop on Parallel Graphics and Visualization (2002)
Distributed Rendering of Interactive Soft Shadows
M. Isard, M. Shand and A. Heirich
- IEEE Parallel Visualization and Graphics Symposium (1999)
Scalable Distributed Visualization Using Off-the-Shelf Components
A. Heirich and L. Moll
- IEEE Symposium on Field Programmable Custom Computing Machines (1999)
Sepia: Scalable 3D Compositing Using PCI Pamette
L. Moll, A. Heirich, and M. Shand



Los Alamos National Laboratories, Advanced Computing Laboratory



Bruckschen, Kuester, Hamann and Joy (2001)

“Real time out-of-core visualization of particle traces”

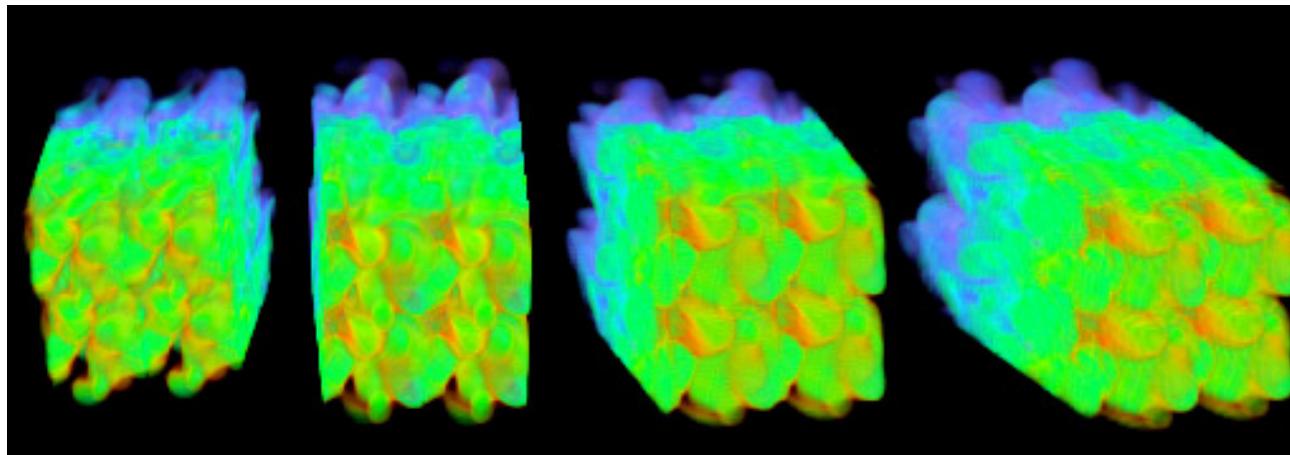
surface rendering, reflection, commutative



Demonstration:
512³ voxels
1024² pixels
24-28 fps
8 computers



*volume rendering,
transmission,
non-commutative,
(associative)*

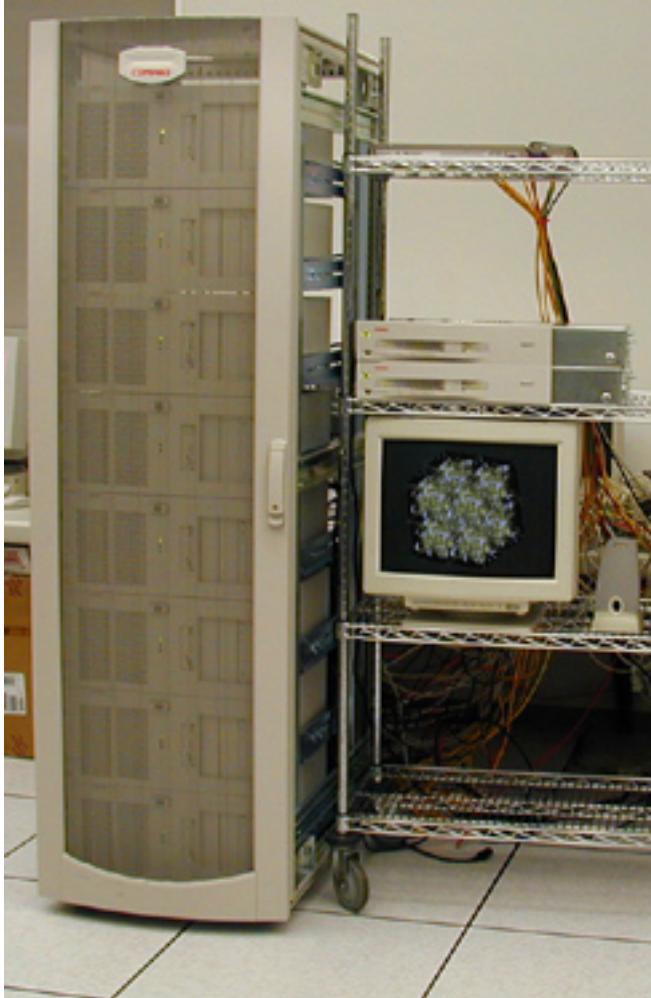


Lombeyda, Shand, Moll, Breen & Heirich, PVG2001

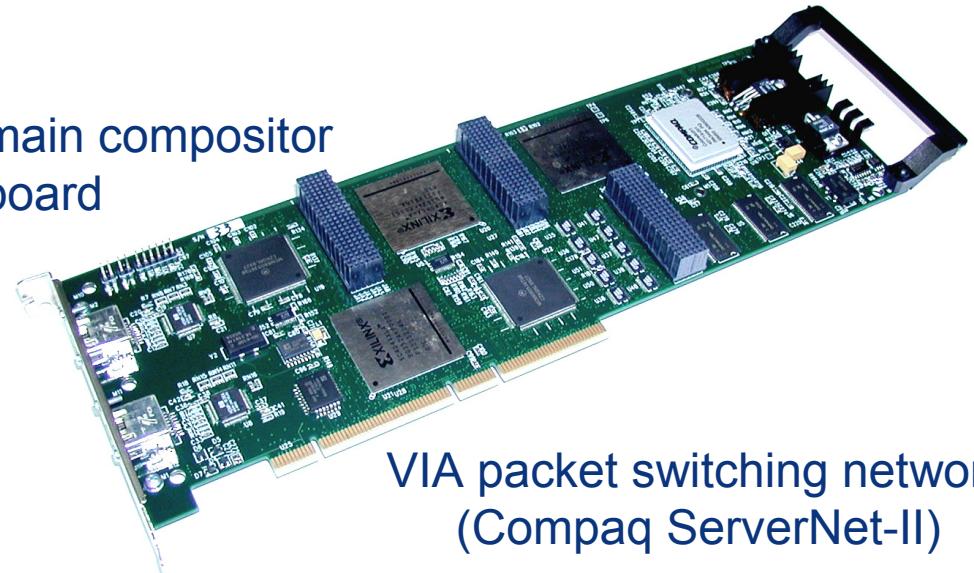


Sepia-2a prototype (2002)

compositing network with programmable arithmetic

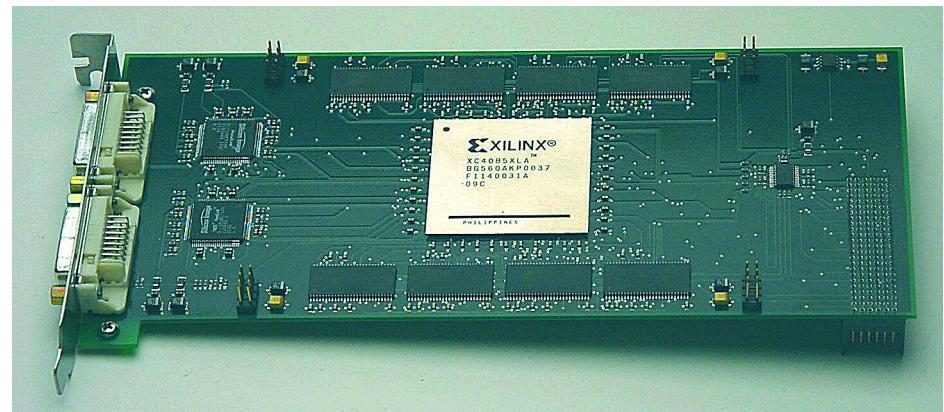


main compositor
board



VIA packet switching network
(Compaq ServerNet-II)

DVI I/O daughterboard



Sepia ray-casting 2001

subvolume bricks 256x256x256
500 MV/s ray-casting engine
shear-warp algorithm
master/slave application
8+1 Pentium-III workstations

3.5 GV/s sustained
512x512x512 voxels
1024x1024 pixels
24-28 fps

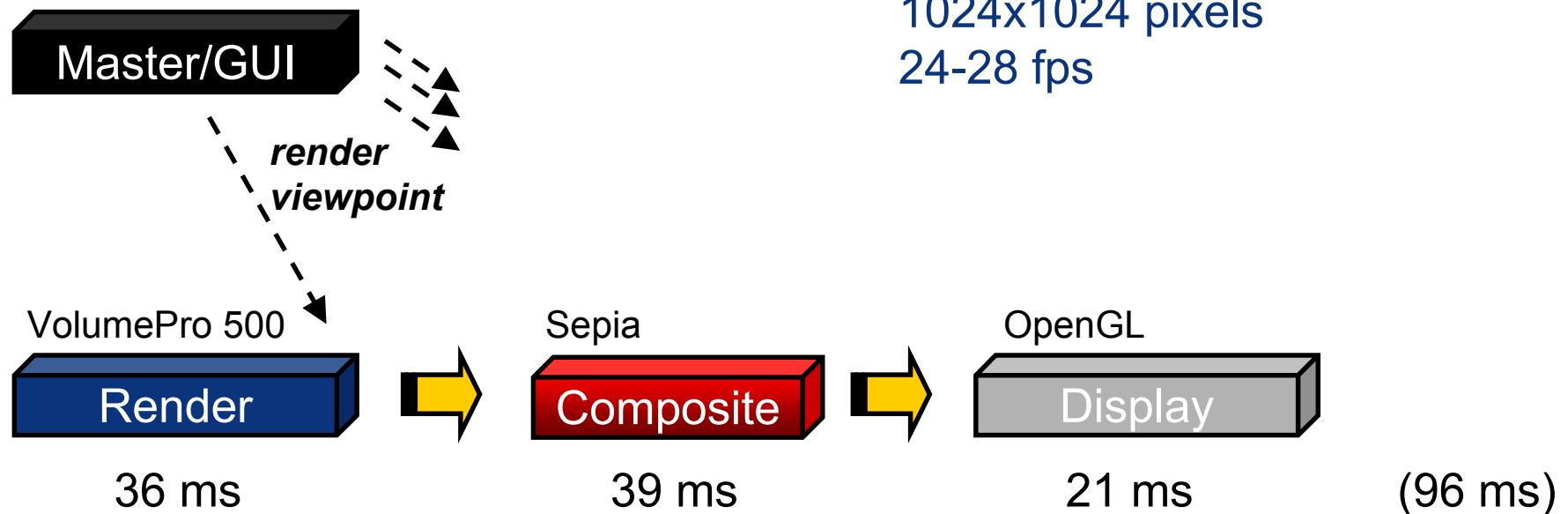
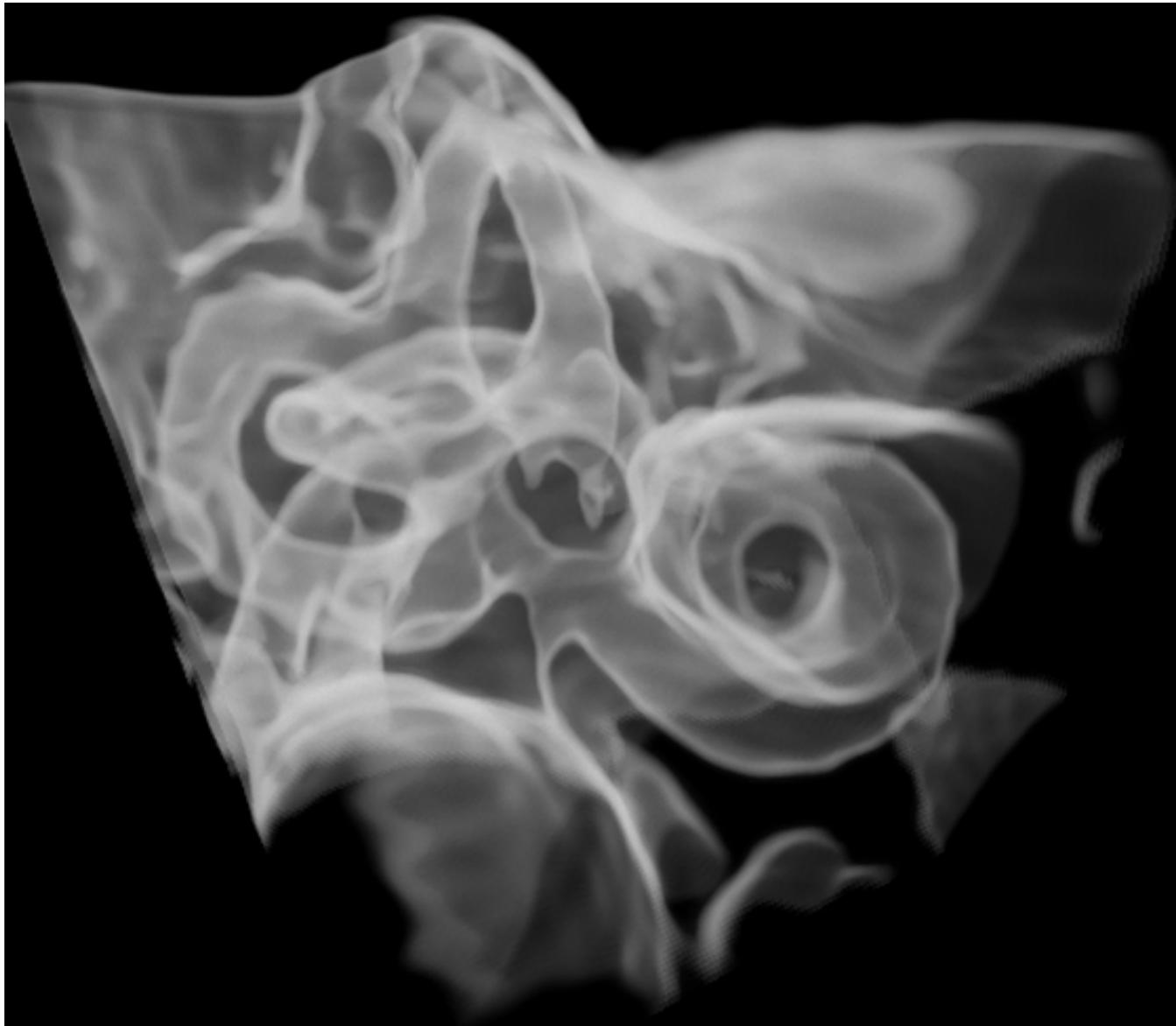


Figure-of-Merit FOM = (Data MV) * (Image MP) * (Frames per second)

Name	Yr	FOM (x 10 ⁻¹²)	GV/ s	Platform	GPU	GPU #	Data MV	Image MP	FPS
Binary swap <i>Ma-LANL</i>	94	1	.004	CM-5 Sparc	Software ray-cast CM-5	512	16	0.25	0.25
Visual Super-computer <i>Ma-Mitsubis</i>	01	380	0.6	Pentium-III	TeraRec Volume Pro 500	8	128	0.5625	4.8
Chromiu m <i>Stanford-LLNL</i>	02	528	1.87	Pentium-III	NVIDIA GeForce -3	16	128	0.25	15
Sepia ray-cast <i>HP-Caltech</i>	01	4,000	3.5	Pentium-III	TeraRec Volume Pro 500	8	128	1.0	28
Sepia OpenGL	02	tbd	tbd	Pentium-IV	ATI or NVIDIA	8-12	128	1.831	tbd
TRex <i>LANL</i>	01	10,000	5	Origin2K MIPS	SGI Infinite Reality-2	16	1024	1.831 (inferred)	5



Engel, Kraus & Ertl (2001)

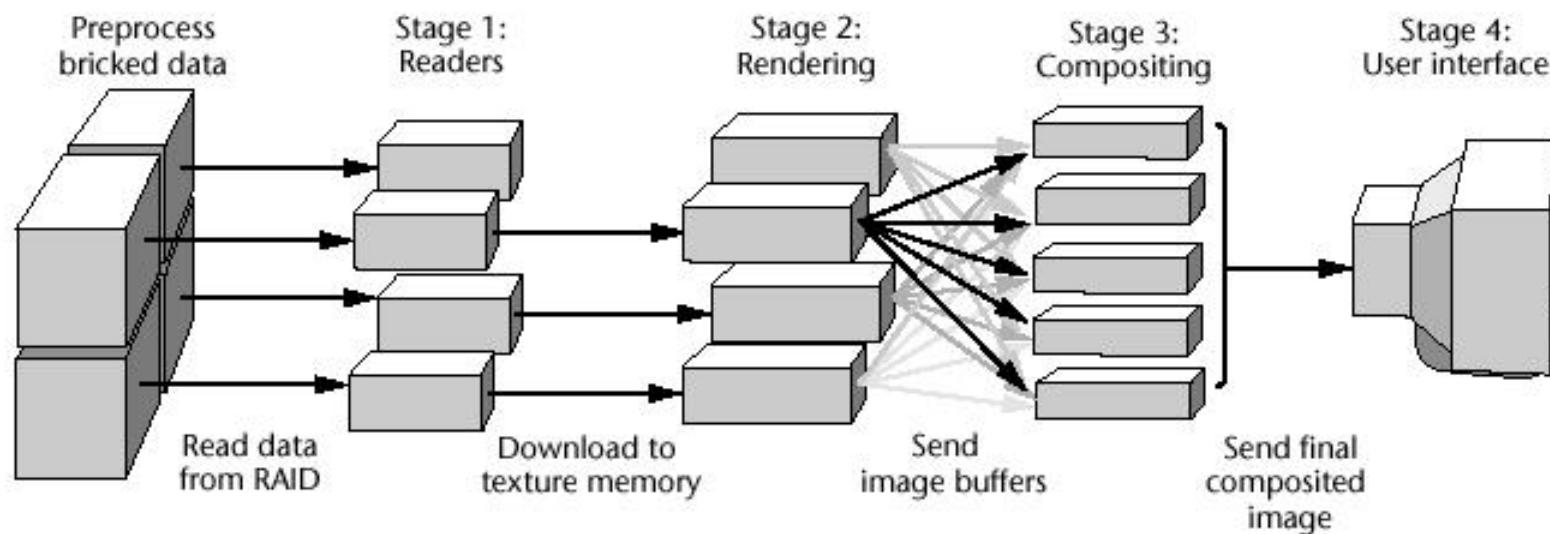
*"High quality pre-integrated volume rendering
using hardware-accelerated pixel shading"*



TREX texture mapping 2001

OpenGL 3D texture mapping
three threads per accelerator
SGI Origin2000, 128 CPUs
16 InfiniteReality-2 OpenGL

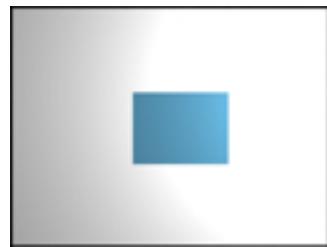
5 GV/s sustained
1024x1024x1024 voxels
5 fps



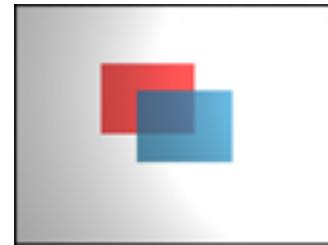
Kniss, McCormick, McPherson, Ahrens, Painter, Keahey and Hansen, IEEE CG&A 2001



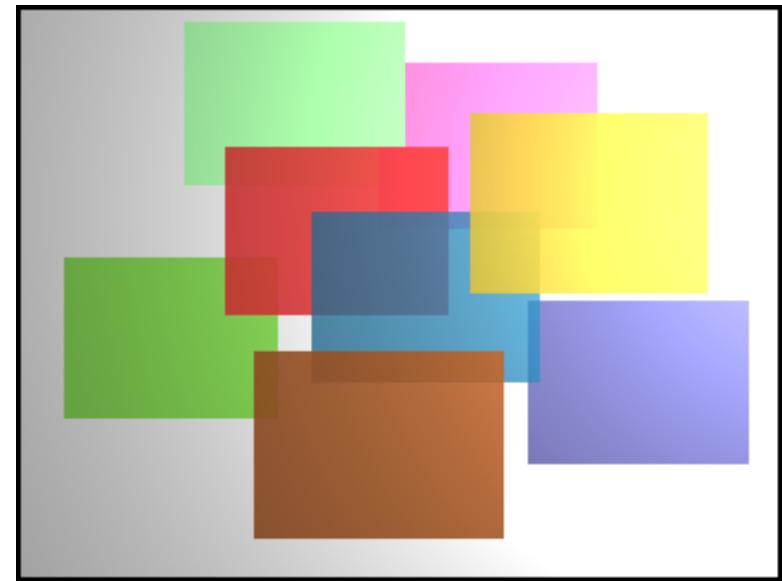
Programming model – Virtual Frame Buffer



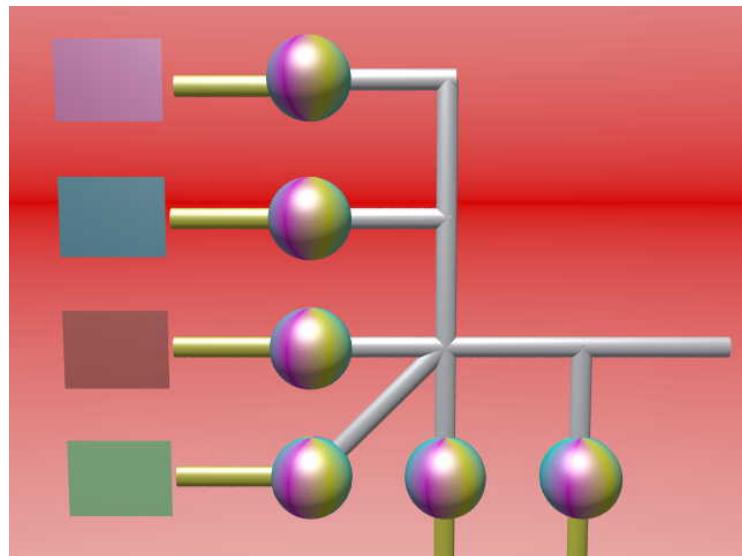
I/O = 1
Composites = 0



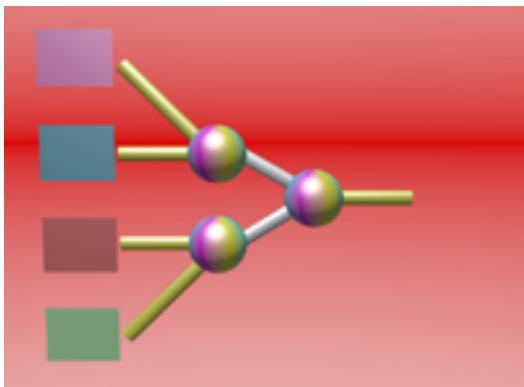
I/O = 2
Composites < 1



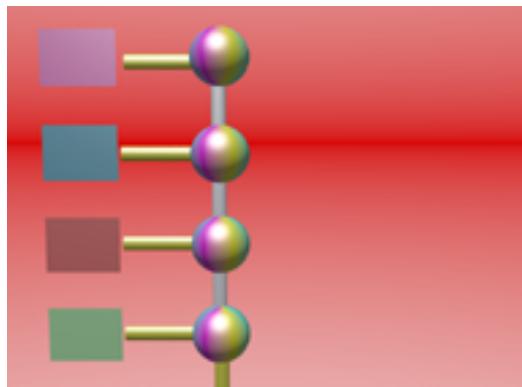
I/O = n
Composites < n



HP Sepia O(n)



Sony GScube O(n)



**HP PixelFlow O(n)
(UNC PixelFlow)**

Sepia with Clos topology:

n compositors

cn switches, p ports each

if p=16:

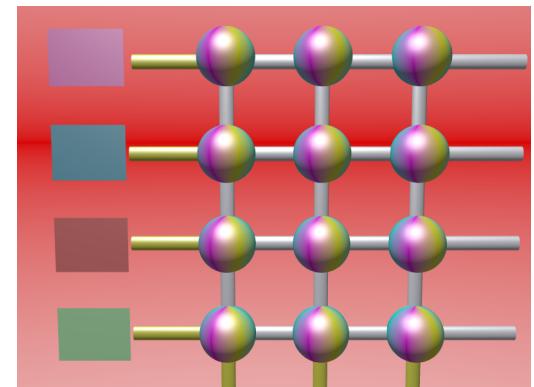
c = c1 for n in 1..128

c = c2 for n in 129..8192

Sepia with linear topology:

n compositors

n / (p-2) switches

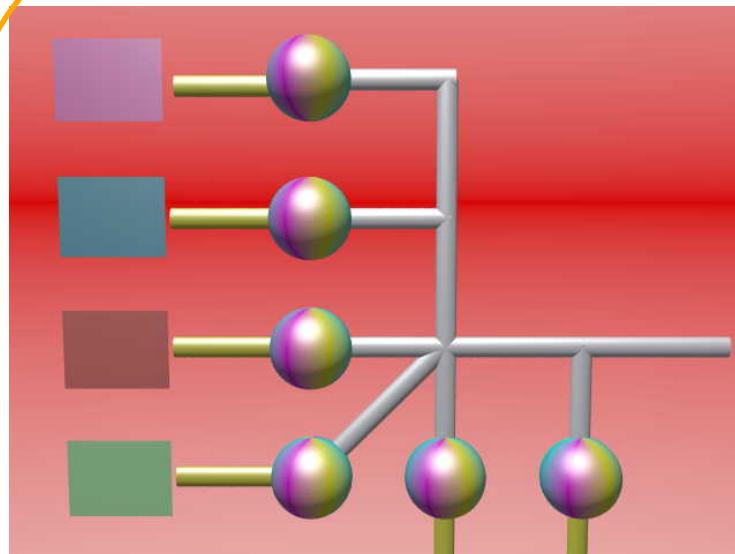


**Intel Illuminate O(n^2)
(Stanford Lightning-2)**



*Cluster
architecture*

*Embedded
architectures*



HP Sepia O(n)

Sepia with Clos topology:

n compositors

cn switches, p ports each

if p=16:

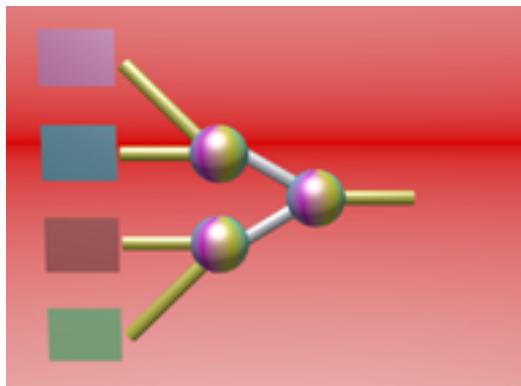
c = c1 for n in 1..128

c = c2 for n in 129..8192

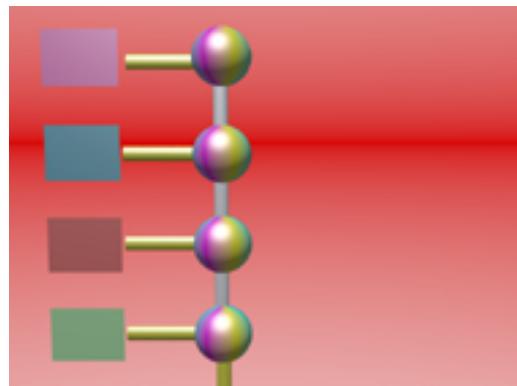
Sepia with linear topology:

n compositors

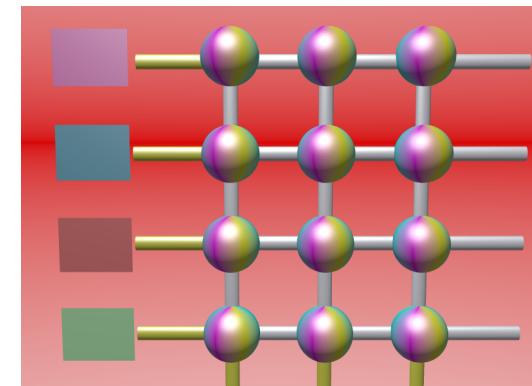
n / (p-2) switches



Sony GScube O(n)



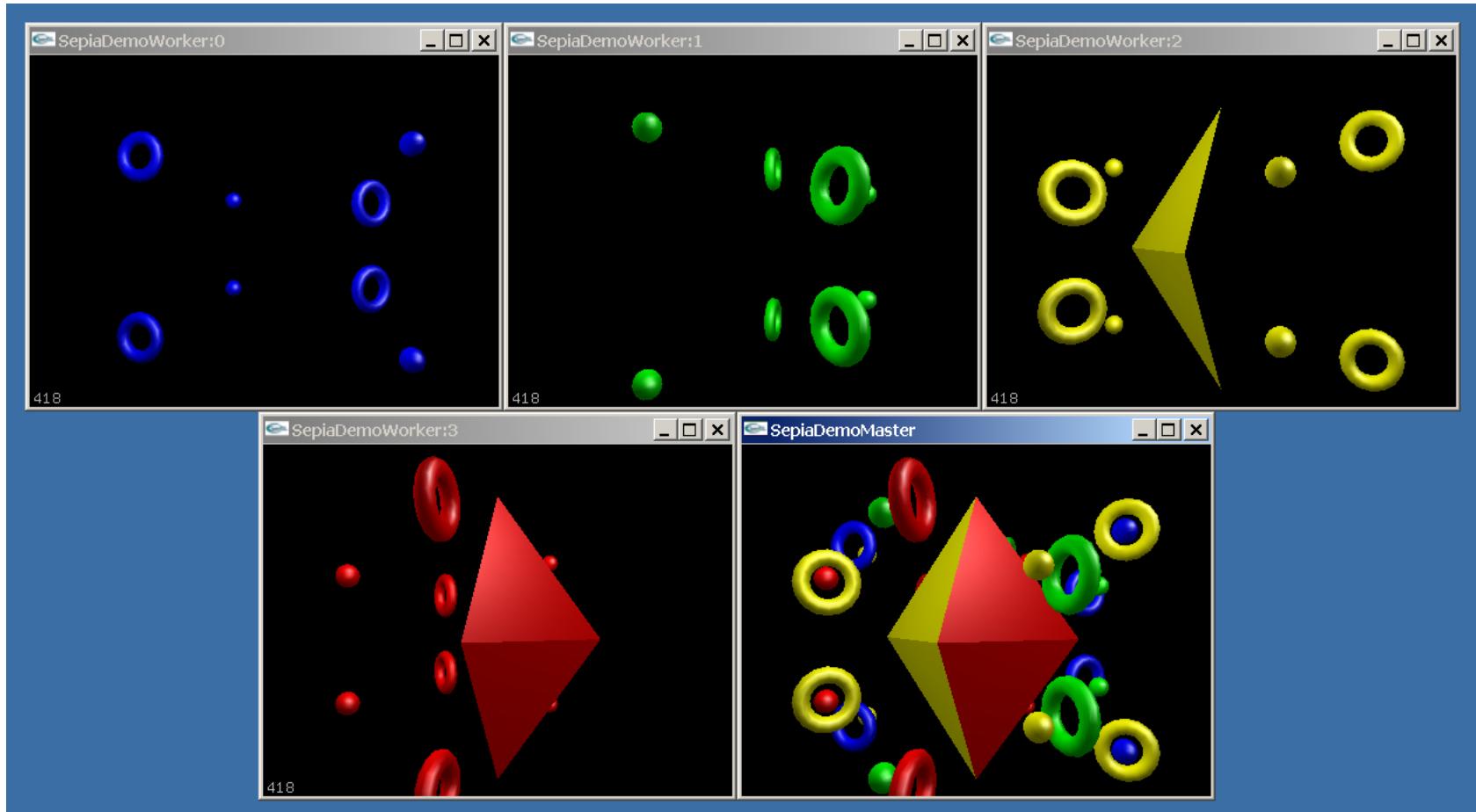
**HP PixelFlow O(n)
(UNC PixelFlow)**



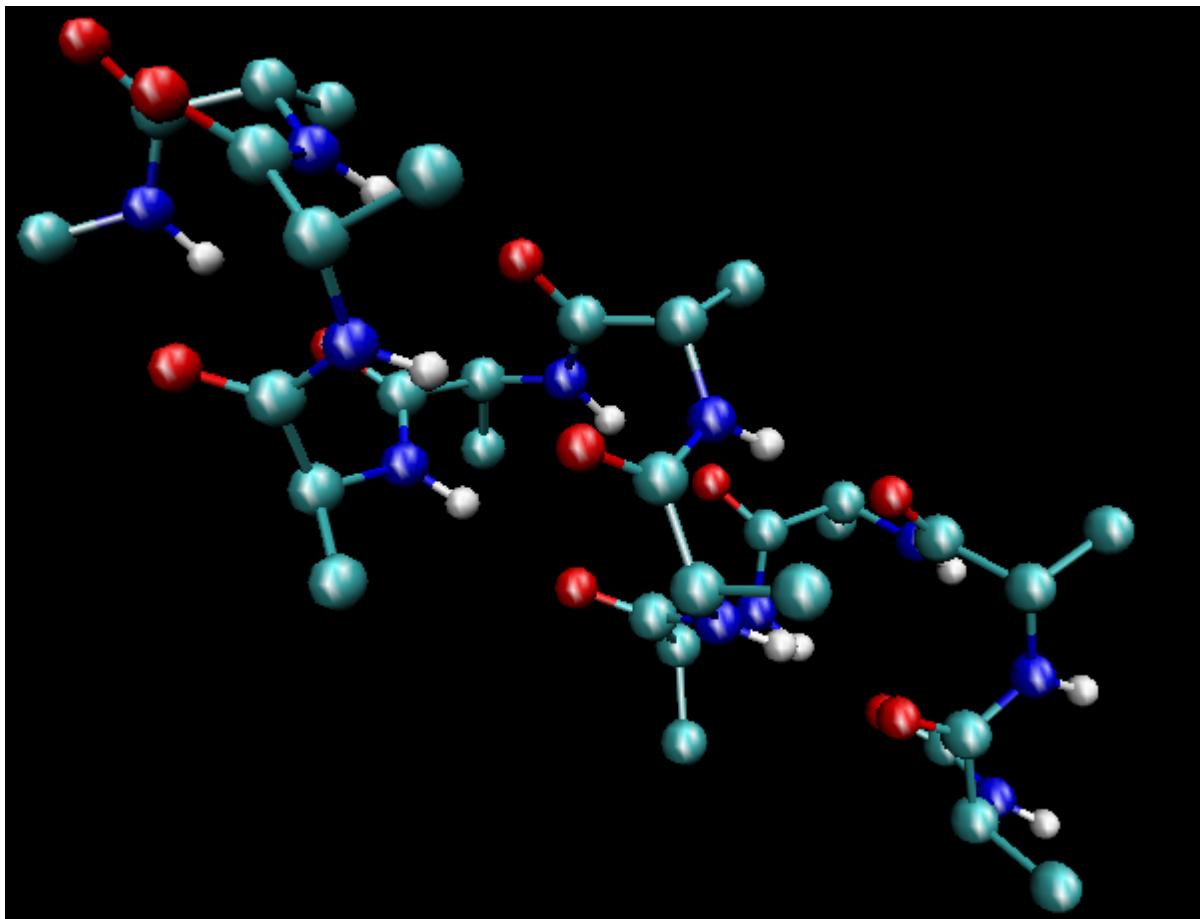
**Intel Illuminate O(n²)
(Stanford Lightning-2)**

Depth-compositing – illustration

Models light transmission (commutative arithmetic)

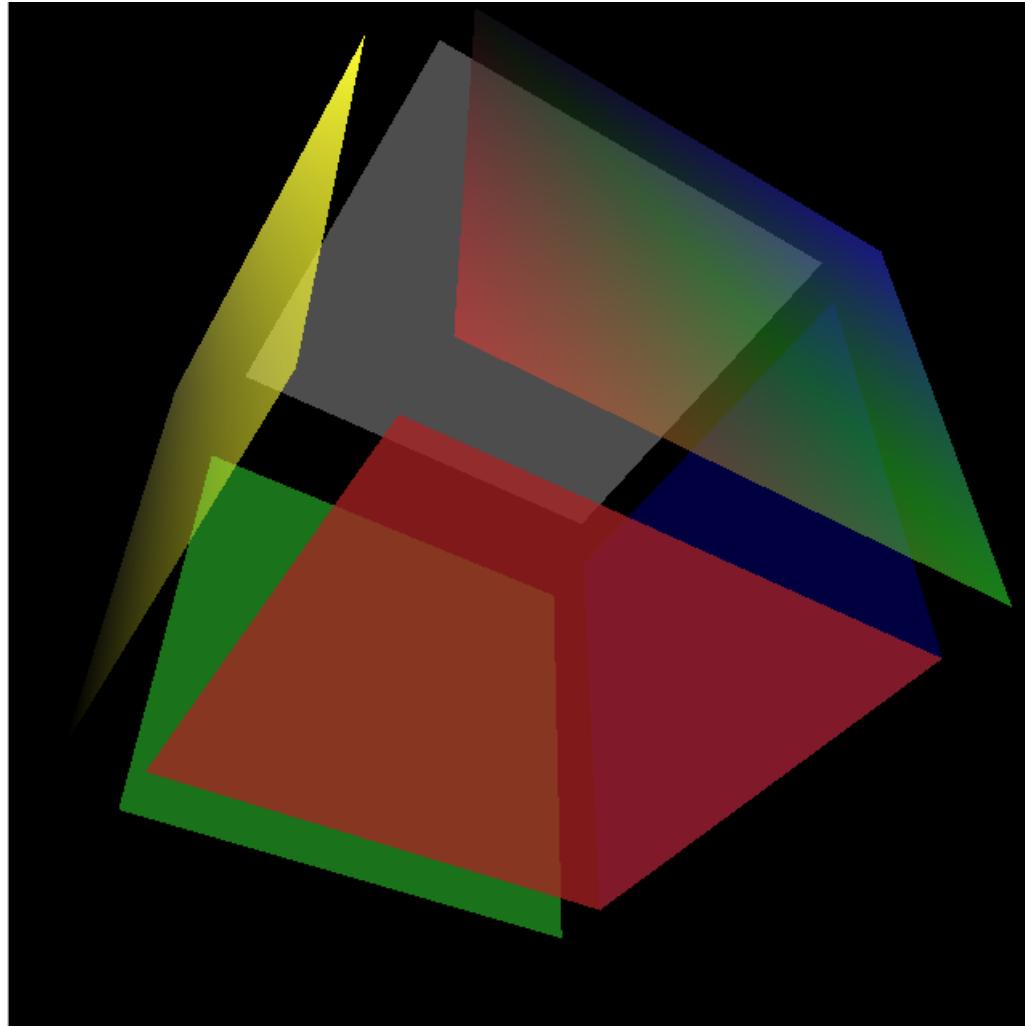


Depth-compositing – VMD (UIUC)



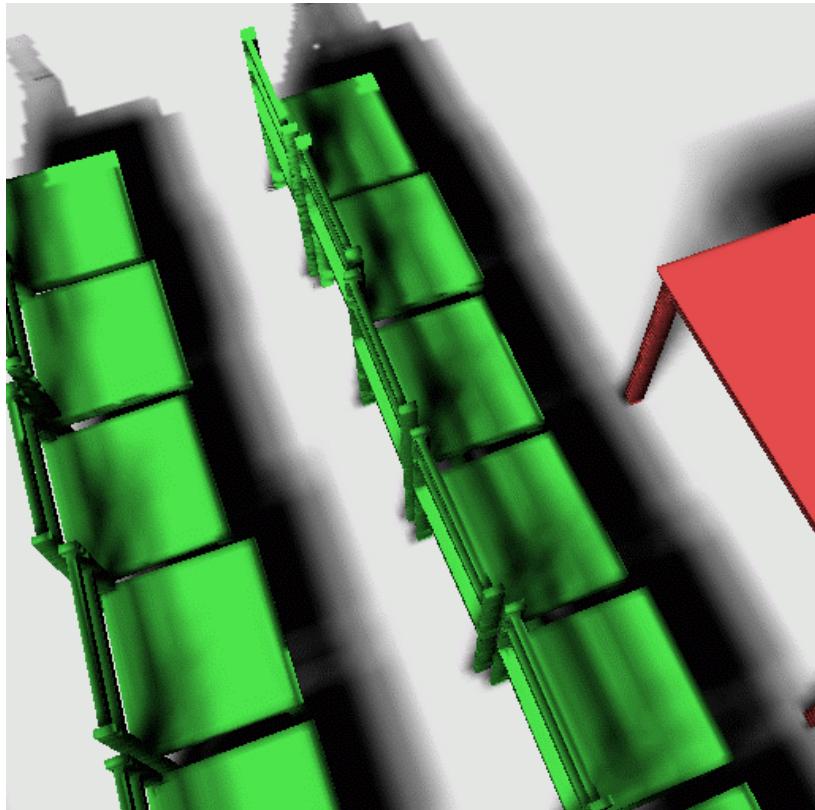
- Molecular visualization program for displaying, animating, and analyzing large biomolecular systems such as proteins
- Performance metric is frame rate of rotating view
- Simple parallelization, scaling depends on load balance

Translucency (non-commutative)

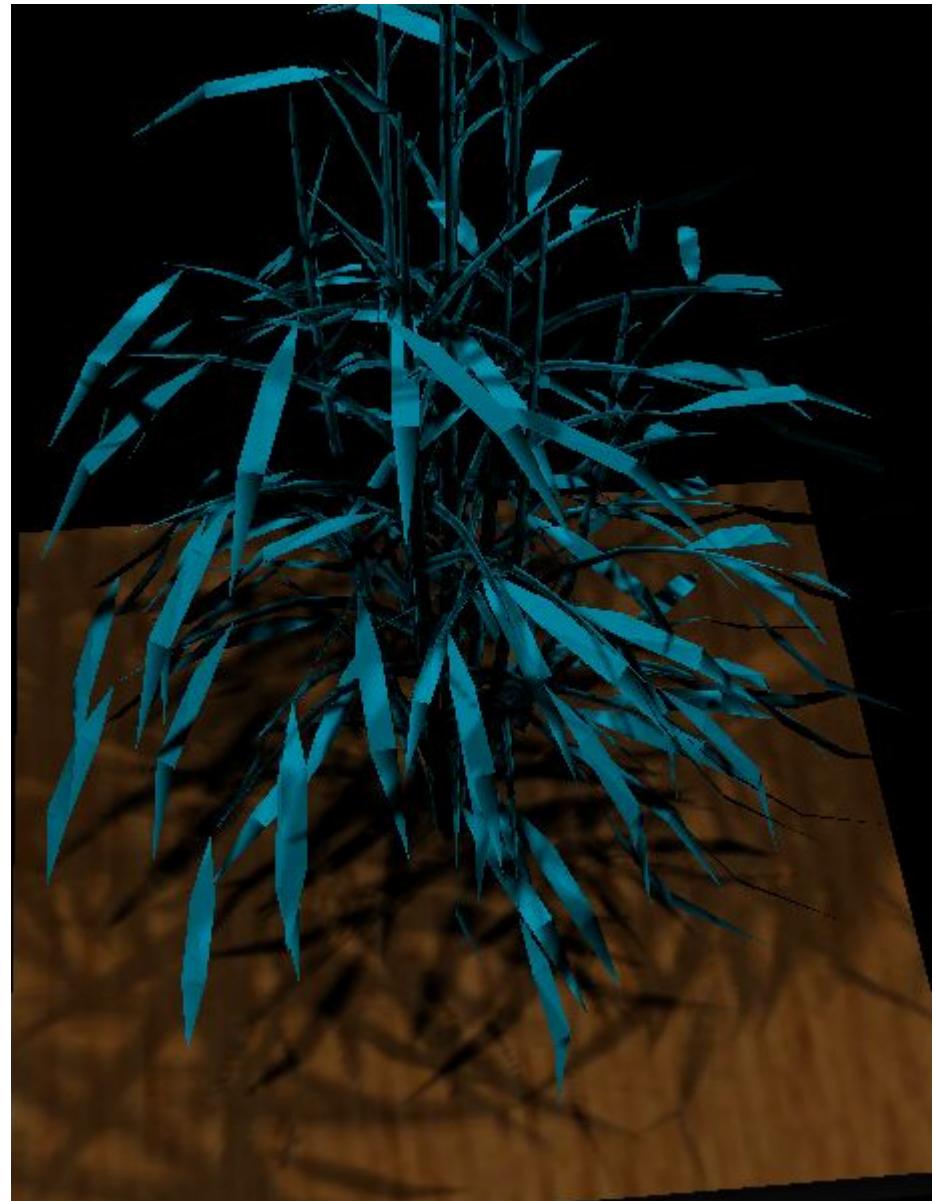


- Models light transmission
- Blending arithmetic is order-dependent (non-commutative)
- Concurrent evaluation requires associative formulation
- Equivalent to Porter-Duff translucency in Linux XFree86
- Solved by packet-switching

Scalable lighting (soft shadows)



Agrawala, Ramamoorthi, Moll & Heirich, SIGGRAPH 2000



Isard, Heirich and Shand, Eurographics PGV2002



i n v e n t

